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(54) **SYSTEM AND METHOD USING IMPULSE RADIO TECHNOLOGY TO TRACK AND MONITOR PEOPLE UNDER HOUSE ARREST**

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(58) Field of Search **340/505, 539, 340/568.1, 572.1, 573.1, 573.4, 10.41, 10.6, 991, 573.7**

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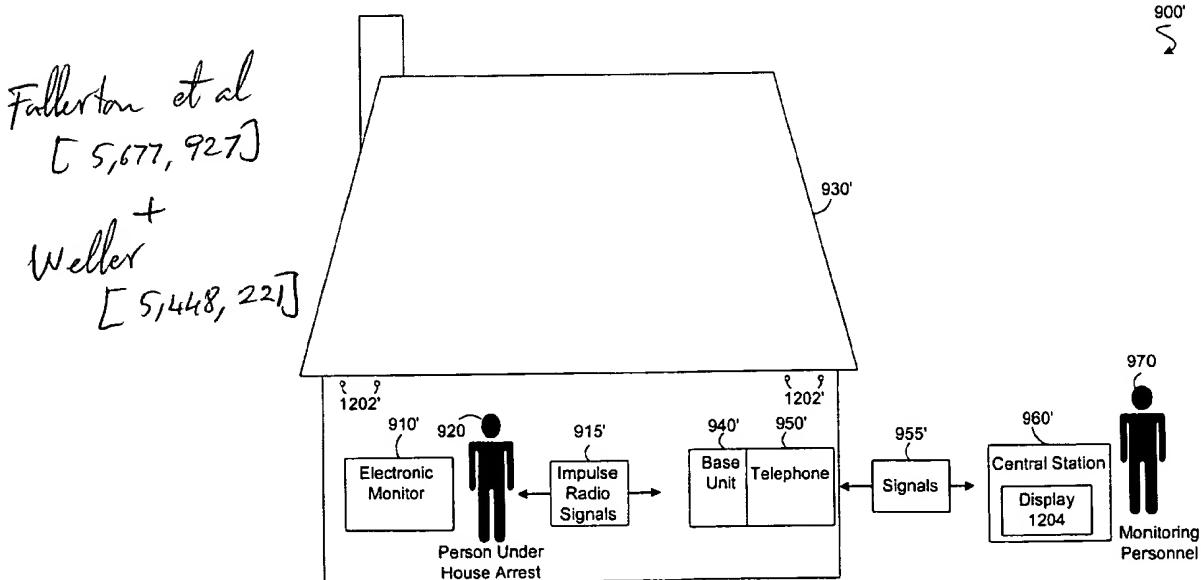
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(57) **ABSTRACT**

A system, electronic monitor and method are provided that utilize the capabilities of impulse radio technology to overcome the shortcomings of conventional house arrest monitoring systems. One embodiment of the present invention enables monitoring personnel (e.g., police officers, parole officers) to determine whether a person under house arrest and carrying an electronic monitor stays within their home. Another embodiment of the present invention enables monitoring personnel to determine whether a person under house arrest and carrying an electronic monitor is located within their home and/or also enables monitoring personnel to monitor the vital signs of that person.

35 Claims, 22 Drawing Sheets



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impulse radio positioning networks can implement and use steerable null antennae to help improve the impulse radio distance calculations. For instance, all of the reference impulse radio units R1-R4 or some of them can utilize steerable null antenna designs to direct the impulse propagation; with one important advantage being the possibility of using fewer reference impulse radio units or improving range and power requirements. The electronic monitor M1 can also incorporate and use a steerable null antenna.

Referring to FIG. 25, there is illustrated a diagram of a specialized difference antennae architecture capable of being used in an impulse radio positioning network. The reference impulse radio units R1-R4 of this architecture may use a difference antenna analogous to the phase difference antenna used in GPS carrier phase surveying. The reference impulse radio units R1-R4 should be time synched and the electronic monitor M1 should be able to transmit and receive.

Referring to FIG. 26, there is illustrated a diagram of a specialized directional antennae architecture capable of being used in an impulse radio positioning network. As with the steerable null antennae design, the implementation of this architecture is often driven by design requirements. The reference impulse radio units R1-R4 and the mobile apparatus A1 can incorporate a directional antennae. In addition, the reference impulse radio units R1-R4 are likely time synched.

Referring to FIG. 27, there is illustrated a diagram of an amplitude sensing architecture capable of being used in an impulse radio positioning network. Herein, the reference impulse radio units R1-R4 are likely time-synched. Instead of the electronic monitor M1 and reference impulse radio units R1-R2 measuring range using TOA methods (round-trip pulse intervals), signal amplitude is used to determine range. Several implementations can be used such as measuring the "absolute" amplitude and using a pre-defined look up table that relates range to "amplitude" amplitude, or "relative" amplitude where pulse amplitudes from separate radios are differenced. Again, it should be noted that in this, as all architectures, the number of radios is for illustrative purposes only and more than one mobile impulse radio can be implemented in the present architecture.

From the foregoing, it can be readily appreciated by those skilled in the art that the present invention provides a system, electronic monitor and method for monitoring whether the person under house arrest stays within or around their home. In another embodiment of the present invention there is provided a system, electronic monitor and method for tracking the location of a person within their home and/or monitoring the vital signs of that person. Also, the present invention enables monitoring personnel to communicate with or eavesdrop on a person.

Although various embodiments of the present invention have been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it should be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

What is claimed is:

1. A system comprising:
an ultra wideband impulse radio transmitter capable of transmitting an impulse radio signal and further capable of being attached to a person under house arrest;
- an ultra wideband impulse radio receiver capable of initiating an alarm for monitoring personnel located

near a central station whenever the ultra wideband impulse radio receiver fails to receive the transmitted impulse radio signal indicating that the person has moved out of a receiving range of the ultra wideband impulse radio receiver; and

a plurality of reference ultra wideband impulse radio units distributed at known locations within or near a home, wherein said central station is further capable of displaying a current position of the person within or near the home that was determined from the interaction between the ultra wideband impulse radio unit and at least two of the reference ultra wideband impulse radio units.

2. The system of claim 1, wherein said ultra wideband impulse radio transmitter is an electronic monitor.

3. A method for tracking a person under house arrest, said method comprising the steps of:

attaching, to the person, an ultra wideband impulse radio transmitter capable of transmitting an impulse radio signal; and
alerting monitoring personnel located near a central station that the person is no longer within a receiving range of an ultra wideband impulse radio receiver whenever the ultra wideband impulse radio receiver fails to receive the transmitted impulse radio signal; determining a current position of the person within or near a home by enabling the ultra wideband impulse radio unit to interact with a plurality of reference ultra wideband impulse radio units that are distributed at known locations within or near the home; and
displaying, at the central station, the current position of the person within or near the home.

4. The method of claim 3, further comprising the step of alerting monitoring personnel that the person has tampered with the ultra wideband impulse radio transmitter.

5. The method of claim 3, wherein said ultra wideband impulse radio transmitter is an electronic monitor.

6. An electronic monitor comprising:
a fastening mechanism capable of attaching said electronic monitor to a person under house arrest;
an ultra wideband impulse radio transmitter, coupled to the fastening mechanism, capable of transmitting an impulse radio signal to an ultra wideband impulse radio receiver that is capable of alerting monitoring personnel whenever the ultra wideband impulse radio receiver fails to receive the transmitted impulse radio signal; and
said ultra wideband impulse radio unit is operable to interact with a plurality of reference ultra wideband impulse radio units such that monitoring personnel can track the position of the person within or near a home, wherein the position of the person is determined by: synchronizing the reference ultra wideband impulse radio units;

synchronizing the ultra wideband impulse radio unit to the synchronized reference ultra wideband impulse radio units;
collecting and time-tagging range measurements between the ultra wideband impulse radio unit and at least two of the reference ultra wideband impulse radio units; and
calculating the position of the person within or near the home carrying the electronic monitor containing the ultra wideband impulse radio unit using the collected and time-tagged range measurements.

7. A method for tracking and monitoring a person under house arrest, said method comprising the steps of:

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attaching, to the person, an ultra wideband impulse radio unit;
 determining a position of the person within or near a home from the interaction between the ultra wideband impulse radio unit and at least two of a plurality of reference ultra wideband impulse radio units distributed at known locations within or near the home;
 receiving, at a central station, information from the ultra wideband impulse radio unit relating to the person;
 displaying, at the central station, at least a portion of the information relating to the person including the position of the person within or near the home; and
 using the ultra wideband impulse radio unit and another ultra wideband impulse radio unit at the central station to establish two-way communications between monitoring personnel at the central station and the person, wherein the ultra wideband impulse radio unit is used to determine the position of the person and also used to establish the two-way communications between the monitoring personnel and the person.

8. The method of claim 7, wherein the information relating to the person includes a monitored vital sign of the person.

9. The method of claims 7, wherein at least one of said reference ultra wideband impulse radio units further supports an ultra wideband impulse radar operation which enables the at least one reference ultra wideband impulse radio unit to sense the movement of another person not carrying an ultra wideband impulse radio unit within or near the home.

10. The method of claim 7, further comprising the step of determining a position of the person located outside the home using Global Positioning System (GPS) based technology.

11. The method of claim 10, wherein said step of determining a position of the person located outside the home using GPS based technology further includes tracking the person.

12. The method of claim 7, wherein said step of displaying further includes indicating an alarm whenever the person roams outside of the home.

13. The method of claim 7, further comprising the step of indicating an alarm, at the central station, whenever the person tampers with the ultra wideband impulse radio unit.

14. The method of claim 7, wherein said step of using further includes enabling the monitoring personnel using the central station to eavesdrop on the person.

15. The method of claim 7, wherein said step of using further includes enabling the monitoring personnel using the central station to notify the person that a rule has been violated.

16. The method of claim 7, wherein said step of using further includes enabling the monitoring personnel using the central station to verify the identity of the person using voice recognition technology.

17. The method of claim 7, further comprising the step of coupling a sensor to the ultra wideband impulse radio unit, wherein the sensor is capable of monitoring at least one vital sign of the person.

18. The method of claim 7, further comprising the step of determining a position of the person within a working environment using ultra wideband impulse radio technology.

19. A system comprising:
 an electronic monitor, attached to a person under house arrest, including an ultra wideband impulse radio unit capable of transmitting an impulse radio signal containing information relating to the person;

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a plurality of reference ultra wideband impulse radio units distributed at known locations within or near a home at least two of which interact with the ultra wideband impulse radio unit to enable the determination of a position of the person;

a central station capable of obtaining the information and further capable of displaying at least a portion of the information relating to the person including the position of the person within or near the home;

said central station including an ultra wideband impulse radio unit that interacts with the ultra wideband impulse radio unit attached to the person to establish two-way communications between monitoring personnel at the central station and the person, wherein the ultra wideband impulse radio unit attached to the person is used to determine the position of the person and also used to establish the two-way communications between the monitoring personnel and the person.

20. The system of claim 19, wherein said electronic monitor further includes a sensor capable of monitoring at least one vital sign of the person.

21. The system of claim 19, wherein at least one of said reference ultra wideband impulse radio units further supports an ultra wideband impulse radar operation which enables the at least one reference ultra wideband impulse radio unit to sense the movement of another person not carrying an electronic monitor within or near the home.

22. The system of claim 19, wherein said central station is further capable of displaying a position of the person located outside the home using Global Positioning System (GPS) based technology.

23. The system of claim 19, wherein said central station is further capable of alerting monitoring personnel whenever the person roams outside of the home.

24. The system of claim 19, wherein said central station is further capable of alerting monitoring personnel whenever the person tampers with the electronic monitor.

25. The system of claim 19, wherein said monitoring personnel using the central station are capable of eavesdropping on the person.

26. The system of claim 19, wherein said monitoring personnel using the central station are capable of notifying the person that a rule has been violated.

27. The system of claim 19, wherein said monitoring personnel using the central station are capable of verifying the identity of the person using voice recognition technology.

28. The system of claim 19, wherein said central station further comprising the step of determining a position of the person within a working environment using ultra wideband impulse radio technology.

29. An electronic monitor comprising:
 a fastening mechanism operable to attach said electronic monitor to a person confined to a home;

a sensor operable to monitor at least one vital sign of the person;

an ultra wideband impulse radio unit operable to interact with said sensor such that monitoring personnel can monitor the at least one vital sign of the person;
 said ultra wideband impulse radio unit is operable to interact with a plurality of reference ultra wideband impulse radio units such that monitoring personnel can track the position of the person within or near a home; and

an interface unit operatively coupled to said wideband impulse radio unit which interacts with a remote central

station including an ultra wideband impulse radio unit to establish two-way communications between monitoring personnel at the central station and the person, wherein the ultra wideband impulse radio unit attached to the person is used to determine the position of the person and also used to establish the two-way communications between the monitoring personnel and the person.

30. The electronic monitor of claim 29, wherein at least one of said reference ultra wideband impulse radio units further supports an ultra wideband impulse radar operation which enables the at least one reference ultra wideband impulse radio unit to sense the movement of another person not carrying an electronic monitor within or near the home.

31. The electronic monitor of claim 29, further comprising a Global Positioning System (GPS) receiver capable of interacting with a plurality of GPS satellites such that

monitoring personnel can track a position of the person located outside the home.

32. The electronic monitor of claim 29, wherein said interface unit is operable to sound an alarm whenever the person roams outside of the home.

33. The electronic monitor of claim 29, further comprising an interface unit is operable to sound an alarm wherever the person tampers with the electronic monitor.

34. The electronic monitor of claim 29, wherein said interface unit enables monitoring personnel to eavesdrop on the person.

35. The electronic monitor of claim 29, wherein said interface unit enables monitoring personnel to verify the identity of the person using voice recognition technology.

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